receiving more attention, at the present time, than these objects, and in general the motion of the stars in the line of sight. The Lick, Yerkes, Greenwich, Potsdam, Bonn and Ottawa observatories are only a portion of those directing a large part of their energy to this subject.

One of the most important generalizations of recent times is the discovery by Professor Campbell that the velocity of a star depends upon its class of spectrum. The proper motion of a star was similarly found by the late Lewis Boss to be dependent on the same quantity.

In conclusion, the United States has attained an enviable position in the newer departments of astronomy. Can this be maintained? In Europe, especially in Germany, observatories and instruments of the highest grade are now being constructed, the government furnishing appliances with the most liberal hand. Perhaps the most promising sign for the future is the friendly cooperation of American astronomers, which has never been more marked than at the present time.

The possibilities of work are now greater than ever before. A small fraction of the effort expended in teaching science if devoted to its extension and progress would fulfil the objects of the American Association for the Advancement of Science.

EDWARD C. PICKERING

PROGRESS OF THE CHEMISTRY OF AGRICULTURE[1]

IT is the object of this address to present briefly the important recent advances made in agricultural chemistry. In so doing, it is not my intention to go back one hundred years or fifty years or even to the period included in the memory of the veterans of this association; but only to consider such a period as is within the memory and the experience of a youngster like myself.

Agricultural chemistry is so closely interwoven with the other sciences which have been applied to agriculture, that it is practically impossible to disentangle them. Hence, to a certain extent, the progress of the chemistry of agriculture is closely related to the progress of other agricultural sciences, and to agricultural science, in general. The contributions of the chemist to agricultural science have been so many, so varied and so important, that for a long time the sciences applied to agriculture have been termed agricultural chemistry. This period is passing, and the term agricultural chemistry is being more restricted in its significance, but the field is still broad, and the harvest bountiful to the worker who seeks to garner the grain of knowledge.

There has been a tendency in some colleges to discontinue the teaching of agricultural chemistry, and to divide the subject-matter between the agronomist and the animal husbandman. It is a serious question whether such tendency is in accord with the known laws of specialization in science. There is no doubt but that, as time goes on, the agricultural chemist must specialize more and more in one of these fields of work, but there is a difference between the specialization of the scientist in his own field, and the attempt of other branches of agricultural science to take over the work of the chemist, or the chemist to take over other branches of agricultural science. As I see it, both the agronomist and the animal husbandman have their special problems. They must have their special training in their own fields, and while this training must include some chemistry, it is not sufficient in quantity to

[1] Presidential address before the Association of Official Agricultural Chemists of North America (November 18, 1913).

make them into chemists in addition. On the other hand, the chemist must be, first of all, a chemist. The agricultural chemist must have knowledge of soils and animal nutrition, but he should have predominant chemical training and chemical methods of thought. The agronomist and the animal husbandman undoubtedly need the aid of the chemist in the solution of their problems; but they should not seek, at one and the same time, to be both agronomist and chemist. The result of such an effort is either an agronomical chemist or a chemical agronomist. It often results in the chemist becoming also the agronomist. What agricultural science needs is the highly-trained agronomist, working, where needs be, in cooperation with a highly-trained chemist who has perhaps specialized in soils and fertilizer chemistry, each assisting and aiding the other. The same is true of the animal husbandman. We need the animal husbandman, highly trained in his field and with a full knowledge of its peculiar problems, working in cooperation with the agricultural chemist, highly specialized in the chemistry of animal nutrition. In this way, we shall avoid those errors which we so often see when a man enters into a field outside of his special training—errors which the specialist immediately recognizes. The truth of the matter is, that the chemist has made such great contributions to the field of agricultural science, that the agronomist and the animal husbandman have, in many cases, not been able to see their own peculiar problems, but have emphasized the chemical side of the subject. They have not wholly found themselves. In some institutions, agricultural chemistry is no longer taught. This, we believe, is a mistake. The student needs a thorough grounding in the entire field, such as is given by the agricultural chemist, and he needs to look at agriculture, for a time, from the point of view of the chemist. Specialization should come later.

These matters will adjust themselves in time. We need not fear that the science of agriculture will ever be without the need of the agricultural chemist. Our ranks have not thinned, but each step of progress has rather added to our numbers. The Adams Act, for example, which is one of the most important events in the recent history of agricultural science, has increased the number of agricultural chemists, as well as the number of other agricultural investigators.

The Adams Act, of March 16, 1906, is important, not only from the fact that it increased the number of scientific agricultural workers in the experiment stations, and their facilities for investigation, but because it affords to the experiment stations opportunity for fundamental research work. The passage of the Adams Act indeed marked an epoch in the history of agricultural science. The experiment stations had previously done much valuable work, and accumulated much data, a fact which the passage of the Adams Act itself recognizes. But the experiment stations had such large demands upon them for immediate and practical information, that they had little time for the investigation of fundamental things, no less practical in their final application, but requiring more time, more patience and less obvious in their practical applications. But under the Adams Act, the experiment stations not only may, but must, conduct research. Fundamental and continuous work may be done upon projects which have no present popular appeal, though no one can predict the ultimate effect of such work. The result of the Adams Act has been an increase in personnel and in facilities for the experiment stations, and it has aided in

creating a demand for more highly trained research assistants. It has also tended to raise the standard of scientific publications of the stations. Thus, as I said, with the passage of the Adams Act, the experiment stations entered upon a new period of their existence, one in which fundamental research becomes a much greater portion of their functions than has been the case in the past. It is true that some directors of stations, and some governing boards, do not yet understand the true significance of research, or the qualifications necessary to pursue it. It is true that some station men do not, in their publications, give proper references to previous work, which may have anticipated their own. It is true that in bulletins and in reports of directors, we sometimes find claims of credit for work which are exaggerated, or perhaps the credit belongs elsewhere; claims which are hardly pardonable, even after making all possible allowance for natural exaggerated opinions of one's own work. Such things will pass away. We need more criticism of our agricultural publications—not destructive criticism, but friendly criticism, and friendly controversies over disputed points. Criticism of the proper kind is a stimulant to good work, and aids in pruning away excrescences such as those mentioned above.

The Adams Act created a demand for men capable of research in agricultural chemistry, and other lines of agricultural science. Research is not an ordinary qualification, even in young men just graduated from college. The ability to do research work must be founded upon a natural ability and inclination towards such work, developed by broad general training, and wide knowledge of some particular science, and by an apprenticeship under one who is himself a master of research. This apprenticeship may be during a course of work and study for the degree of Doctor of Philosophy; but it may also be in the process of regular station work under some eminent station investigator. We must recognize the fact that all men capable of research have not been able to secure the Doctor's degree, even though they have done equivalent work. The ability to do research work may be developed by study and training, but it can not be created.

The Adams Act thus marks an important step in the progress of agricultural chemistry, other agricultural sciences and agriculture, as a whole. Perhaps equally as significant was the passage of the National Food and Drugs Act, approved June 30, 1906. Taken in a broad way, the passage of this act was one of a series of events in the reaction of the people against dishonest commercial practises. It has become evident that the people will no longer tolerate practises which have crept into use, which are morally wrong, but were formerly considered as all right because they were business; practises which deceive the buyer or give unfair advantages in business competition. Business has been a species of warfare, but just as it is now contrary to the laws of civilized warfare to kill women and children and burn private dwellings, so it is becoming contrary to the laws of business warfare to cheat women and children and to deceive the purchaser as far as possible. How much the agitation for the pure food and drug law had to do with this moral awakening, no one can say, but no doubt this crusade of twenty-two years had much to do with it—a crusade by an agricultural chemist, Dr. Harvey W. Wiley, for many years chief of the Bureau of Chemistry; secretary of the Association of Official Chemists from its organization until only a little more than a year ago, now our hon-

orary president—for whom all of us have a warm place in our hearts.

The Food and Drugs Act has resulted in a material clearing of the atmosphere, with respect to the naming, labeling and adulteration of foods, drugs and feeds. We now have very clearly defined the objects of such a law. These are, first, to prevent the sale of any unwholesome or deleterious substance, and second, to ensure that the goods delivered to the purchaser shall be exactly as represented. These principles have been made clear, not only with respect to foods and drugs, but also with respect to feeds, and feed manufacturers are beginning to realize that a mixture of bran and screenings may no longer be sold as bran, or a mixture of corn bran and corn chops, sold as corn chops. There are some feed manufacturers who have not yet read aright the signs of the times, as, for example, some of the manufacturers of cottonseed meal, who contend for the authority to sell a mixture of meal and hulls under the name of cottonseed meal, but undoubtedly the time will come when this matter will be made clear.

This association has played an important part with respect to food adulteration. Before 1900, there was one referee and one associate on this subject. At the 1900 meeting, provision was made for 14 associate referees, and there are now 21 associate referees. In addition, we have our committee on food standards, which has done valuable work.

In the matter of cattle feeds, their analysis and adulteration, it appears this association has done little in recent years. The analysis and control of these feeds are yearly assuming a greater importance. There should be a referee and an associate referee on the adulteration of feeds and methods for their detection. We have no official methods on this phase of the subject, beyond the ordinary analysis. The method for crude fiber should be thoroughly studied, and perhaps modified. The clause which permits filtration through cloth should be eliminated. The estimation of crude fiber is becoming more and more important, for by its use we can detect more easily the addition of materials rich in crude fiber, to concentrated feeds. The estimation of crude fiber, for example, shows much more clearly the probable quantity of cottonseed hulls in cottonseed meal, or rice hulls in rice bran, than does any estimation of protein and fat.

Striking progress has been made in recent years in the study of soils. This applies especially to the survey and mapping of soils. In this work, the Bureau of Soils is easily the leader. There is a tendency in some quarters to regard the survey, mapping and analysis of soils as an end in itself. It is true that such work is highly important, but it should also be regarded as a basis on which to make further soil investigations so that we may become fully familiar with the properties and characteristics of each type. In a sense, the soil survey should be regarded as the beginning of soil studies.

In other respects our knowledge of soils has been increased by recent investigations. We now know more concerning the nature and constituents of the organic matter of the soil, and something more concerning its biological properties. We also know that, on an average, the needs of the soil for fertilizer nitrogen in pot experiments is related to the total nitrogen of the soil. We know that the active potash of the soil is related to the average needs of the soil for potash in pot experiments, and that plants have the power to exhaust the active potash and to take up more potash than they need. We know that, on an average, the active phosphoric acid of the soil is re-

lated to the needs of the soil for phosphoric acid in pot experiments. The relation of the pot experiments, and the analysis, to field needs, must be worked out. Soils also deviate from the average, as regards their plant food content and behavior to pot experiments; such deviations must be studied and their causes ascertained. There is much to be done, but progress is being made.

In the field of animal chemistry, decided progress has been made in recent years. We must now recognize the possibility, that, in digestion, proteids of different kinds may be split into different products, some of which may be unfit for use as structural material in building up animal proteids, and so must be discarded. We know that this is possible, but we have not yet secured positive evidence that such occurs with any of the various proteids fed domestic animals. Such studies may be expected in the future.

It has been shown, without doubt, that the digested materials of different feeds have different values to the animals. One pound of digestible nitrogen-free extract in corn has a much greater value than one pound of digestible nitrogen-free extract in straw. The fact that there is a difference in the values of digested nutrients of the same class but from different feeds has been clearly shown by the work of Kellner and of Armsby. There is no doubt about it. It is a step forward to recognize the differences in the values of the digested nutrients and to adjust our tables, our rations and our calculations accordingly. There is abundant room for work along this line, but enough work has already been done to justify this advance. Nearly every American book which deals with the feeding of animals still assumes that the digestible nutrients of one feed are equal in nutritive value, pound for pound, to the digestible nutrients of the same class in any other feed. These books must be re-written and adjusted to our latest advances in knowledge. This advance will, to a certain extent, reconcile the differences between the effects of feeds or of rations in feeding experiments which, under the old standards, should have apparently the same nutritive values.

We are now able to state the nutritive value of a feed in terms of three factors: its bulk, which satisfies the hunger of the animal; its proteids, which repair flesh or tissue, or which, in excess, may be used for fat or energy; its fat-producing value, which is its ability to furnish the animal with heat or energy or to form fat. The fat-producing value of a feed or nutrient is determined experimentally. First, the fattening animal is fed a ration which produces a slight gain of fat, and the gain of fat is measured by determining the income and outgo of carbon and nitrogen. Next, the nutrient or feed is added to this ration, and the gain in fat again determined. The difference in the quantity of fat produced is due to the added feed or nutrient.

The results of such work can be readily compared with calculations based on the assumed equality of the same group of nutrients in different feeds. While the calculated value of peanut meal or linseed meal is practically equal to that found, the value for a wheat straw is only 20 per cent. of that calculated, of meadow hay 54 per cent., of rye bran 79 per cent. of that calculated.

It should be clear that the recent advances in the chemistry of animal nutrition compel us to modify materially tables of feeding values, rations, and methods of calculation. There is opportunity for useful and valuable work along the lines of determining exactly the productive values

of feeds and nutrients, and such work may be expected in the future.

In the thirteen years of the twentieth century the progress of agricultural chemistry has been such as to satisfy even the pessimist that we are moving forward. Our facilities for scientific investigation have been increased by the Adams Act. Our supervision over foods, drugs and feeds has been enlarged and rendered more effective through the Federal Food and Drugs Act. We have made great progress in the survey and mapping of soils and in our knowledge of their properties and chemical composition. The science of animal nutrition has made such advances as to render it necessary to revise almost all books dealing with the subject, and to modify our methods of stating the nutritive values of feeds, and our methods of calculating rations for feeding animals. These have been the four chief lines of advance of agricultural chemistry in recent years. The members of the Association of Official Agricultural Chemists may well take pride in the part they have taken in the progress that has been made.

G. S. FRAPS

THE NEW YORK STATE VETERINARY COLLEGE AT CORNELL UNIVERSITY

THIS occasion[1] is to commemorate the opening of a suitable hospital for large and small animals and halls for the teaching of veterinary medicine. It has greater significance than the mere addition of new buildings to our working equipment, for it introduces into the teaching of clinical medicine methods of precision which heretofore could not be employed. We believe it is desirable that the public should know what the university and the state are doing to increase the efficiency of the veterinary profession.

In the development of veterinary medicine in America, Cornell University holds a conspicuous place. It was the first institution of higher learning to place veterinary medicine on par with other sciences. When its doors opened in 1868, there was among its professors a veterinarian. A department of veterinary medicine was established and it continued as such until 1896. During those twenty-eight years, the head of that department, our distinguished and beloved Dr. Law, was not only an adviser in university affairs, but also a leader in the important work of the nation in eradicating those diseases of cattle that cost Great Britain and her colonies hundreds of millions of dollars. Had it not been for the broad views of Ezra Cornell and President White relative to the teaching of applied sciences in Cornell University, where Daniel E. Salmon, Theobald Smith and Leonard Pearson were trained, the losses on British soil from contagious pleuropneumonia, piroplasmoses and foot and mouth disease might easily have been duplicated in this country.

At the time the department of veterinary science was organized in the university, it was not thought in this country to be necessary to expend large sums of money for veterinary education. The American people experienced with the resignation of the fatalist a steadily increasing loss from diseases of animals. Because of the enormous live stock industry and export trade in cattle and animal products, this loss was not generally felt. The time was approaching, however, when our meat and dairy products would be required to feed our own people and when the losses sustained from disease would be added to the cost of living. This condition was as inevitable here as it had been in Great Brit-

[1] Opening of hospital and clinic buildings, New York State Veterinary College at Cornell University, November 15, 1913.